

Research Highlight

The representation of deep convection in general circulation models is in part informed by cloud-resolving models (CRMs) that function at higher spatial and temporal resolution; however, recent studies have shown that CRMs often fail at capturing the details of deep convection updrafts. With the goal of providing constraint on CRM simulation of deep convection updrafts, ground-based remote-sensing observations were analyzed and statistically correlated for four deep convection events observed during the Midlatitude Continental Convective Clouds Experiment (MC3E). Since positive values of specific differential phase (KDP) observed above the melting level are associated with deep convection updraft cells, so-called “KDP columns” were analyzed using two scanning polarimetric radars in Oklahoma: the National Weather Service Vance WSR-88D (KVNXX) and the Department of Energy C-band Scanning Atmospheric Radiation Measurement (ARM) Precipitation Radar (C-SAPR). KVNXX and C-SAPR KDP volumes and columns were then statistically correlated with vertical winds retrieved via multi-Doppler wind analysis, lightning flash activity derived from the Oklahoma Lightning Mapping Array, and KVNXX differential reflectivity (ZDR). Throughout, the Python ARM Radar Toolkit (Py-ART) was used to process and grid radial radar data.

When intense updrafts occur inside of thunderstorms, a common characteristic is the lofting of rain and/or liquid-coated hail to heights well above the environmental melting level. These hydrometeors are observable by polarimetric radars, due to the oblateness of these hydrometeors, as positive enhancements in KDP and ZDR that are roughly collocated with the updraft location. KDP and ZDR columns thus provide an observational proxy for deep convection updrafts, updrafts that are usually only detectable by non-attenuating profiling radars, or derivable by multi-Doppler radar networks. Here we objectively identified KDP columns using a simple, but robust, object-identification algorithm. For each KDP column, horizontal and vertical extent, and maximum retrieved vertical velocity were quantified, together with storm-total KDP column volume, ZDR column volume, and lightning flash frequency.

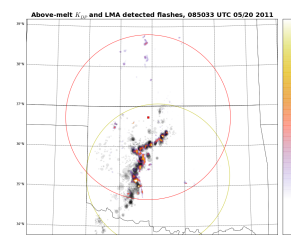
Our work showed strong correlations of KDP volume above the melting level with updraft mass flux, lightning flash activity, and intense rainfall. These correlations confirm the usefulness of KDP columns for the observational detection and analysis of deep convection updrafts. Weaker correlations were observed between KDP column height and multi-Doppler estimated updraft strength, and together with temporally lagged correlations between KDP column statistics, updrafts, and lightning activity, suggest that future work should focus on observations of the full lifecycle of deep convection updrafts. KDP column heights were shown to be variable between days studied and also show variability within a single day, in accordance with changes in storm morphology. Comparison of ZDR to KDP showed commonalities in the information content of each, as well as potential problems with ZDR associated with observational artifacts, such as differential attenuation, and the reduction in ZDR when radar volumes are contaminated by large hail. These findings suggest that KDP should be used together with ZDR to identify and track deep convection updrafts.

Reference(s)

van Lier-Walqui M, AM Fridlind, AS Ackerman, S Collis, J Helmus, DR MacGorman, K North, P Kollias, and DJ Posselt. 2015. "On polarimetric radar signatures of deep convection for model evaluation: Columns of specific differential phase observed during MC3E." *Monthly Weather Review*, eView, 10.1175/MWR-D-15-0100.1. ONLINE.

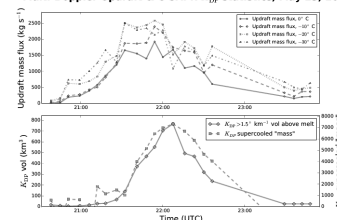
Contributors

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KDP, integrated in a 3km slab above the melting level, from NWS Vance OK S-band polarimetric radar (colors), shown with contemporaneous Oklahoma Lightning Mapping Array flashes (black circles), during the May 20, 2011 storm observed at SGP during MC3E. Red and yellow circles show the approximate maximum ranges of radar and lightning mapping array, respectively.

Multi-Doppler Updraft & C-SAPR K_{DP} statistics, May 23, 2011



Updraft ($w > 1\text{m/s}$) mass flux at four levels from multi-Doppler wind retrieval, KDP $> 1.5 \text{ }^\circ/\text{km}$ volume above the melting level and KDP “supercooled mass” from the C-SAPR radar (see text) on May 23, 2011.

Working Group(s)

Cloud-Aerosol-Precipitation Interactions

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